The window of locational opportunity-concept*

Dr. Ron Boschma

University of Twente
Faculty of Public Administration and Public Policy
Department of Goverment and Public Policy
P.O.Box 217
7500 AE Enschede
The Netherlands
phone: +31-53-4894554 / 4893260
fax: +31- 53-4892255
e-mail: r.a.boschma@bsk.utwente.nl

february 1996

Abstract

This article aims to set out a theoretical concept, *i.e.* the *Window of Locational Opportunity* concept, which accounts for notions like indeterminacy, human agency and historical accidents when explaining the spatial pattern of newly emerging industries.
We will state that their spatial formation does probably not reveal predictable tendencies of necessity and regularity during their initial stage of development, because structures, conditions and capabilities laid down in the past are unlikely to determine their spatial manifestation. Potential impacts of space are considered to be highly unpredictable: latent triggers or incentives providing opportunities and/or challenges are manifold, while the selection environment may

* The author greatly acknowledges the hospitality and support he got from the Dipartimento di Scienze Economiche of the University of Bologna during his stay as a visiting researcher, in particular from the Director of the Department Prof. G. Gambetta, and Prof. A. Reggiani. The many useful comments have been very much appreciated on earlier draft versions of this article from members of the Department such as Prof. P. Bianchi, Prof. B. Menegatti, Prof. V. Negri-Zamagni, Prof. C. Poni, Prof. A. Reggiani, Prof. C. Scarpa and Prof. R. Scazzieri. The author would also like to thank the Netherlands Organization for Scientific Research (NWO) for the financial support he got to do research at the University of Bologna.

operate only very weakly. As a consequence, we will claim that notions of human agency and accidents are necessitated to `explain' the spatial pattern of new industries. Because there is much uncertainty about the site where new industries will emerge, windows of locational opportunity tend to open up in the event of newly emerging industries: this theoretical concept holds the view that the long-term evolution of the spatial system is potentially, but not necessarily unstable.

1. Introduction

One of the principal topics in economic evolutionary thinking is to provide explanations for the emergence of novelty (Hodgson, 1993). There is much debate about the extent to which novelties may be determined by specific circumstances, or should be regarded as the outcomes of chance events. This chance-necessity controversy may also throw light on another debate concerning the nature of the dynamics of technological evolution in particular and economic development in general, which is a topic central to evolutionary theory (Nelson, 1995). This relates to the problem whether novelties reflect gradual, continuous or dramatic, discontinuous tendencies of change. These conflicting views about the nature of change in systems, known as a controversy between the gradualist approach and the punctuated equilibrium perspective (see, for instance, Hall, 1994) can also be found in other scientific fields, such as biology (Monod, 1972), philosophy of science (Kuhn, 1970), physics (Prigogine and Stengers, 1984) and economic history (Mokyr, 1991).

Economic geographers are dealing with similar questions. On the one hand, they are much interested in analyzing the driving forces behind the spatial pattern of major technological innovations, *i.e.* the extent to which chance and necessity may be involved in their spatial manifestation. On the other hand, they explore the way these novelties may affect the evolution of spatial economic systems, *i.e.* whether these bring about the rise of new growth regions at the expense of old industrial regions (Scott, 1988). In this chapter an attempt is made to address both problems from a particular spatial angle. This is done by introducing the Windows of Locational Opportunity (WLO)-concept (Boschma, 1994). To this end, we will focus attention on the problem as to how to explain the location of major innovations that give birth to new industries (such as the transistor, the integrated circuit and the micro-processor that led to the emergence of a new computer industry). First, we will discuss whether indeterminacy, human agency and chance rather than deterministic mechanisms may be involved in the spatial emergence of

new industries. We will conclude, for example, that newly emerging industries are likely to develop rather independently of established spatial structures and conditions. Second, the WLO-concept addresses the fundamental problem whether the ability of regions to generate new industries is likely to be subject to fundamental change in the course of time. With respect to the latter, it emphasizes on a potentially, but not necessarily unstable evolution of the spatial system.

When addressing these items, we will discuss or refer to key concepts in evolutionary thinking (indeterminacy, randomness, selection environment, the cumulative, localised nature of innovation) when these may be helpful to specify and define the main features of the WLO-concept. We will point out, for example, that the selection environment is unlikely to determine where new industries will emerge and prosper in space, due to a mismatch between their new requirements and the existing production environment. As a result of this lack of fitness, new industries will shape and transform the local selection environment according to their needs as their development proceeds.

This chapter is divided in three sections. In Section 2, we will set out the main traits of two particular notions of innovation. The first is the cumulative, localised and primarily incremental concept of innovation, which refers to the evolutionary theory of technical change proposed by Nelson and Winter (1982). The second is the revolutionary, random, unpredictable and disruptive concept of innovation, which has been adopted by (among others) evolutionary reasoning in chaos theory (see, for instance, Leydesdorff and Van den Besselaar, 1994). The two notions of innovation not only throw a different light on the role of chance and necessity when explaining their origins, but these also reflect different views regarding the nature of dynamics involved (gradual versus dramatic change). This will enable us to define more clearly in Section 3 the main features of the WLO-concept, which attempts to come to grips with the mechanisms behind the spatial manifestation of the latter notion of innovation, *i.e.* new industries. As far as the chance-necessity debate is concerned, we will discuss successively in the Sections 3.1, 3.2 and 3.3 whether indeterminacy, human agency and randomness are involved. In other words, we will specify the extent to which the existing environment determines the place where new industries will emerge, *i.e.* the extent to which chance and necessity are involved in their spatial manifestation. We will claim, for instance, that the spatial pattern of new industries is unlikely to reveal predictable tendencies of necessity and regularity, not in the least because spatial structures and conditions laid down in the past are unlikely to determine their spatial manifestation. As far as the nature of change is concerned,

we will focus attention in Section 3.4 on the extent to which the evolution of the spatial system may be subject to fundamental change when new industries emerge, *i.e.* to what extent these novelties require so-called new growth regions rather than old industrial regions to develop. We will relate this to the mechanisms behind the location of new industries described previously in terms of indeterminacy, creativity and randomness. In Section 3.5 we will claim that the rate of discontinuity of the new industry involved may determine what type of spatial change occurs. Section 4 will draw some conclusions.

2. Two notions of innovation

To start with, a distinction will be made between two notions of innovation. We will first discuss the nature, origins and impacts of technical change as defined by Nelson and Winter (1982). It lays emphasis on a localised, cumulative and primarily incremental concept of innovation, which results from the localness of searches for new technologies, the importance of cumulative trajectories of innovative behaviour and the transmission and amplification of feedback between firms operating in clusters. Next, the features of the concept of the discontinuous innovation will be presented, which sharply contrasts with the previous notion of innovation in many respects. This outline will be partly based on insights of the neo-Schumpeterian long-wave theory (Freeman *et al.*, 1982). However, we will also draw from those evolutionary strands that refer to chaos theory in order to underline the catastrophic nature of major innovations (see, for example, Hodgson, 1993) or acknowledge the importance of major innovations because these lay at the roots of new technological trajectories (Dosi, 1982; Silverberg, 1988; Mokyr, 1990). In short, this discontinuous concept takes notice of the indeterminate and unpredictable origins of major innovations or new techno-industrial trajectories, because large numbers of (small, arbitrary) potential triggers and (weak) selecting mechanisms are involved. Moreover, it accounts for the disruptive and destabilizing impacts of major innovations, such as changes in the economic and institutional structure.

This distinction will serve several purposes. The main features of the notion of the discontinuous innovation will be used to construct a theoretical concept in Section 3, which endeavours to come to grips with the mechanisms behind the spatial manifestation of new industries. The outline of the notion of the continuous innovation will be helpful to specify and sharply define the main features of this discontinuous

concept, while it will also make clear that the evolutionary notion of technical change introduced by Nelson and Winter (1982) is rather unfit to address such a research question.

2.1 The notion of the continuity of innovation

The evolutionary theory of technical change as defined by Nelson & Winter (1982) focusses attention on the importance of uncertainty in which the innovation process takes place. Complex and dynamic environments do not provide freely available and readily accessible information. As a consequence, economic actors face uncertainties resulting from a wide range of possible alternative paths of behaviour and the inability of firms to assess the merits and drawbacks of each of these options. In order to cope with this uncertainty, decisions of firms are likely to be guided by *routines* (Nelson and Winter, 1982) or *behavioural rules* (Heiner, 1983). Such attitudes of firms, embedded in skills and experience are likely to show regular, continuous and relatively predictable patterns, because uncertainty requires behaviour to be reduced to simplified patterns while firms have limited awareness of alternatives. As a consequence, firms tend to employ conservative, risk-averse behaviour: they will hesitate moving into unknown territory, because in this case, there is no prior experience to benefit from.

This does, however, not imply that change does not take place. On the contrary, economic actors exhibit innovative behaviour, defined as *changes in routine* (Nelson and Winter, 1982) despite high uncertainty and risks. Nevertheless, innovative behaviour is believed to be guided to a considerable degree by prevailing routines. Firms are considered to carry out so-called *searches*, that have been described by Nelson and Winter (1982) as routine-guided efforts to explore possibilities of routine-changing innovations. This search behaviour is likely to be undertaken locally because uncertainty is more likely to be kept under control when this search is directed to more familiar markets, technologies and existing routines. In fact, when innovative behaviour is regarded as a result of a problem-solving response initiated by perceived troubles with existing routines (stagnant or declining markets, technological anomalies in established routines, or threats of innovative rivals), the latter tend to push firms to look in directions not unrelated to their past achievements. When innovative behaviour is considered to be induced by the challenge of technological opportunity because the use of existing technology offers scope for considerable improvements in the near future, innovations are likely to be closely related to existing products and the

organization of production processes. However, this does not imply that search outcomes may not still be subject to stochastic processes. For example, potential adaptations to a changing environment, although heavily constrained by existing routines may be quite numerous (Hall, 1994). This is why changes in an evolutionary perspective are often described in probabilistic terms.

This historical nature of the continuous notion of innovation may be further illustrated by the fact that innovative behaviour is seen to proceed along specific paths or *technological trajectories* (Dosi, 1982). These are described as regular guidelines of exploratory activities specific to a particular technology, or to a wider range of technologies, so-called *technological paradigms*. This importance of path-dependency implies that the historical accumulation of information, knowledge and experience tends to structure available options and probable outcomes of searches, while it constraints the ability of economic agents to react to changing market signals. Innovative behaviour may show a certain internal logic, that acquires momentum as it proceeds along trajectories. This continuous, cumulative pattern of innovative behaviour along trajectories has often been related to learning processes: The use of a new technology may result in further improvements because new opportunities are identified based on practical knowledge and previously acquired experience (Rosenberg, 1976). On the one hand, this may take place within firms, bringing about the accumulation of firm-specific advantages or competences (Dosi, 1984), especially when `... technology is not a free good, but involves specific, often idiosyncratic, partly appropriable knowledge which is accumulated over time through equally specific learning processes ... ' (Dosi and Orsenigo, 1988, p. 16). This assymetry between firms, the varying techno-industrial positions of firms with regard to a particular *technological frontier* is likely to be consolidated due to firm-specific learning processes, skills, R&D-abilities and economies of scale (Nelson and Winter, 1982; Dosi, 1984). On the other hand, these cumulative, self-reinforcing processes may occur within clusters of closely linked firms. In fact, the transmission, exchange and feedback of technological knowledge, resulting from `... reciprocal stimuli, bottlenecks, information flows, spillovers of technological knowledge, etc.' (Dosi and Orsenigo, 1988, p. 28) may spark off a dynamic innovative process in those firms that are either linked into such a network or have (local) access to these externalities.

This implies that evolutionary change is, to a large extent, cumulative and gradual (De Bresson, 1987). This notion of cumulative innovative behaviour has, in fact, often been associated with series of continuous, small-scale, incremental changes, such as quality

improvements of products and minor cost reductions of production processes. Rosenberg (1982) states that the economic significance of the cumulative effect of many minor, incremental innovations is actually very large, although each of them has a very limited economic impact.

Institutions (industrial associations, universities, government bodies) may be considered part of the selection environment: these regulate and coordinate the behaviour of actors in general and influence innovative behaviour in particular (see Nelson, 1995). The so-called *regulation* approach (Lipietz, 1986; Boyer, 1988) regards the role of the socio-institutional structure as an `... essential underpinning of efficient capitalist production system ...' (Scott and Storper, 1992, p. 5). What is essential here is that this regulatory influence of the institutional environment is believed to support the continuous development of innovative behaviour along trajectories for a long period of time as soon as a wide range of durable institutions has matched their requirements (Freeman and Perez, 1988).

Although this notion of continuous innovation may be regarded as a disequilibrating force, it takes place in a relatively ordered manner (Dosi and Orsenigo, 1988). This may be associated with its main features mentioned above, *i.e.* the continuous and cumulative patterns of technological change along trajectories; the local character of search and imitation in terms of routine-guided adjustments; the relatively stable and self-reinforcing diffusion patterns among clusters of inter-related firms; and the regulatory influence of durable, supporting institutional structures. Further, the selection environment imposes heavy constraints on new technologies that strongly deviate from the established trajectories, even if these novelties possess superior qualities[1]; these will therefore not survive. This brings about stable patterns of dynamic economic development for at least some time.

2.2 The notion of the discontinuity of innovation

Following Schumpeter (1939), major innovative breakthroughs represent dramatic breaks or *quantum leaps* in the direction of techno-industrial development. It is therefore unlikely that the information, knowledge and experience accumulated along trajectories, as stressed by the evolutionary theory of Nelson and Winter may determine or stimulate the appearance of this notion of innovation. In fact, the emergence of major innovations is accompanied by new and unstandardized knowledge and

[1] If such is the case, path dependency has resulted in lock-in.

fundamentally different kinds of information, while qualifications of the labour force, the R&D commitments and the established institutional environment (knowledge infrastructure, capital suppliers, government) are unlikely to be compatible with the new requirements of major innovations. It is even very likely that prevailing routines and institutions act as impediments for the adoption of major innovations (Perez, 1983). As a consequence, discontinuity is regarded as of such a dramatic nature that any specific, predictable influence from past structures and practices may be ruled out. It is, however, important to note that this dramatic nature has not so much to do with the pace of change; it is rather a rule than an exception that the adoption and diffusion of breakthroughs take place rather slowly (Rosenberg, 1976). This may be related to their discontinuity mentioned above.

This lack of positive influence from past events, combined with the numerous hindrances attributed to prevailing routines and the presence of high uncertainties attached to the introduction of major innovations explain why concepts like heroic Schumpeterian entrepreneurship and Keynesian animal spirits have been used to explain why major innovations occur (Freeman and Perez, 1988). The prospect of superprofits, resulting from patent protection, imperfect competition and other first-mover advantages is regarded as the only incentive that makes firms introduce breakthroughs in the economic system. Their discontinuity may also explain why the rise of new industries is often associated with newly emerging firms (Dosi, 1982). The emphasis on firm-specific advantages by the evolutionary theory of Nelson & Winter (1982) provides a powerful explanation for the reluctance of established firms to adopt major innovations. In fact, this inability may be explained by the large gap that exists between the techno-economic competence of existing firms on the one hand and the new requirements of major innovations that deviate strongly from prevailing routines on the other hand (Heiner, 1983)[2].

According to modern evolutionary thinking, the emergence of novelty

[2] However, there may be differences between major innovations concerning their discontinuity. For example, Rosenberg (1976) states that the ability of firms to adapt depends on `... the complexity of the new techniques, the extent to which they are novel or rely on skills already available or transferable from other industries, etc.' (p. 197). In the case of major process innovations (new production methods), it is not impossible that the (established) firms can make use of existing know-how about the product, market demand and existing sale and distribution facilities, which make them fitter to implement these breakthroughs (Teece, 1988). We will discuss this more in detail in Section 3. We will conclude there that only inquiry may determine in each particular case the extent to which firms, regions or countries have fallen back on existing routines and conditions to generate, imitate or apply major innovations.

is subject to a random variation, that stands in sharp contrast to the notion of continuous innovation. Breakthroughs are either regarded as unforeseen, unexpected outcomes of searches (Nelson and Winter, 1982; Mokyr, 1990) or conceived to be induced by small, arbitrary factors analogous to the so-called `butterfly effects' in chaos theory (Dosi, 1982; Silverberg, 1988; Arthur, 1989). We will only briefly analyze here the extent to which major innovations, in spite of their discontinuity may be subject to influences of existing practices and environmental conditions. This topic is likely to throw light on the chance-necessity debate mentioned in the introduction, and will be analyzed more thoroughly in Section 3.3. In short, we will argue that it is impossible to predict which major innovations will emerge, by which specific triggers they are induced, and by which elements of the environment they are selected. The fundamental uncertainty about their sources and impacts is likely to preclude an *ex ante* logic behind the emergence of major innovations in time and space (Silverberg, 1988). Dosi was right when he claimed that it is impossible `... to draw any conclusions on the directions of change of the system without first seeing it moving in each single part' (1984, p. 108).

As far as the uncertainty about the specific impact of triggers providing opportunities and/or challenges is concerned, this is not only because a multitude of small, arbitrary events, that are hard to generalize about, are likely to be involved (Arthur, 1989). This can also be related to the fact that only a few out of an infinite number of potential triggers or *focussing mechanisms* will actually result in breakthroughs (Rosenberg, 1976). As far as the uncertain and unpredictable impact of the selection environment is concerned, this may not only be explained by the fact that this environment contains so many potentially influential elements (a wide range of technological, economic, political and institutional factors) that it is impossible to predict which one(s) will exercise a (decisive) influence. This is also because the favourable impacts of the environment are likely to be rather weak, due to its poor match with the new requirements of major innovations as explained by their discontinuity above[3]. It not only means that major innovations survive despite the fact that they reflect, almost by definition, unfit changes, but it also implies that a technological breakthrough that became dominant after a process of competition between rivals is not necessarily the superior or the most efficient one (see

[3] It should be noted that major innovations are regarded here as historical accidents because indeterminacy is involved, and not because specific environmental conditions happened by chance to match perfectly the needs of these new technologies.

David, 1985; Arthur, 1989). In Section 3 we will argue that the lack of specific stimuli from the environment necessitates firms to create or attract their own supporting conditions, such as input requirements (Storper and Walker, 1989). This favours the view of a dynamic growth process, wherein supporting conditions (skilled labour, useful knowledge and information, dynamic user-supplier linkages, responsive capital suppliers) come into being as the development of new industries proceeds. This view differs from the continuous perspective because such a development process in their initial stage of growth is not based on the presence of favourable conditions. On the contrary, the environment is shaped according to their needs because such a supportive production environment is lacking.

Major innovations are likely to have disruptive and pervasive effects on the economic system. On the micro-level, we already explained why prevailing routines and high adjustment costs may hamper the ability of established firms to divert into totally different fields of technology. On the meso-economic level, major innovations may bring about structural changes, altering and displacing the previously existing economic structure, because breakthroughs have different impacts on the various industries in an economy. Further, institutional structures have to be adjusted because the prevailing institutional environment is probably incompatible with the requirements of new breakthroughs because they are discontinuous (Perez, 1983). On the macro-economic level, it has been stressed by many authors that major innovations may only have a small economic effect unless they occur in clusters (Frischtak and Rosenberg, 1983). In a long-wave perspective, these are believed to pave the way for the resurgence of long-term economic growth, because they offer new opportunities for investments (new markets) and productivity gains, whereas their diffusion is likely to sustain a prosperity phase for some time (Freeman, Clark and Soete, 1982). It is not surprising then that major innovations are often considered a prerequisite for securing the long-term survival of the economic system: they not only overcome limitations of existing structures such as the exhaustion of technological and economic possibilities, but they also break down institutional rigidities enabling new activities to occur (Dockès and Rosier, 1992).

- Table 1 -

The differences between the two notions of innovation are summarized in

Table 1. The features of the notion of discontinuous innovation will be used to construct a theoretical concept in Section 3, which will deal with the mechanisms behind the spatial manifestation of new industries. The notion of continuous innovation may be regarded as unfit to address such a problem, because it neglects the issue of discontinuity. However, we will argue in Section 3.5 that such a framework is more appropriate to describe the spatial formation of new industries when they build on conditions inherited from the past in order to adjust the local environment in accordance with their own needs.

3. Windows of Locational Opportunity

The principles behind the notion of discontinuous innovation will now be applied to develop a theoretical concept, called the `Windows of Locational Opportunity' (WLO), that endeavours to understand the mechanisms of the spatial manifestation of major innovations that give birth to new industries. The WLO-concept partly builds on the work of Scott and Storper (1987), Scott (1988), Perez and Soete (1988) and Storper and Walker (1989).

In the following sections, we will first successively discuss whether indeterminacy, human action and accidental events are involved in the spatial emergence of new industries. By doing so, we will specify the extent to which the existing spatial environment may exercise influence on, or even determine the location where new industries will emerge. In other words, we will define the extent to which chance and necessity are involved in their spatial manifestation. Next, the WLO-concept is applied to the problem whether newly emerging industries will disrupt the long-term evolution of the spatial system, *i.e.* whether the ability of regions to generate novelty is subject to fundamental change in the course of time. It basically regards the problem to what extent these novelties require new growth regions rather than old industrial regions to develop. This will strongly depend upon the mechanisms behind the location of new industries, which has been described in terms of spatial indeterminacy, creativity and randomness. With respect to both matters, the WLO-concept states that new industries are likely to emerge and develop in space rather independently of established spatial structures and conditions, while it lays emphasis on a potentially unstable evolution of the spatial system. This will be illustrated by a few examples taken from a long-term spatial analysis of Great Britain and Belgium (Boschma, 1994).

By doing so, the WLO-concept uses some topics and notions dealt with by modern evolutionary thinking, such as randomness and selection

environment. This concept claims, for example, that the rise of new industries in space, though highly unpredictable is not an entirely accidental outcome because it is often triggered by existing practices and structures that provide challenges or opportunities. Moreover, it states that the selection environment is unlikely to determine where new industries will emerge and prosper in space, due to a mismatch with their new requirements. Because of this lack of fitness, it is wrong to treat the local selection environment as given; newly emerging industries shape and transform their production space according to their needs as their development proceeds.

3.1 Spatial Indeterminacy

To begin with, the discontinuous nature of major innovations set out in Section 2.2 implies that the spatial formation of new industries involves spontaneity or indeterminacy because unlikely to be determined by or bound to particular places. Storper and Walker (1989) assert that because new industries differ from existing ones, they require unique *locational specifications* that need to be met in space in order to support their further development. This discontinuity involves a fundamental problem of adaptation for regions: their own particular histories (trajectories), which have resulted in a particular technological, economic and institutional specialization make them unfit to seize these new opportunities. This can be explained with the assistance of the particular evolutionary framework presented in Section 2.1: there is likely to exist a large gap between the new (locational) needs of new industries and the prevailing techno-industrial structure (the techno-economic competence of firms and industries) and institutional environment in regions. The larger the gap, the higher the adjustment costs related to, for instance, the acquisition of new knowledge, information and skills, and the more difficult it is for regions to draw on available local conditions to restructure their local economies. This negative element of path dependency may explain why old industrial regions are sometimes incapable of generating new technologies that deviate considerably from their established trajectories. In fact, industrial regions may become `locked' into a production environment which is strongly geared to their established techno-industrial structure that they become incapable of responding to any fundamental changes.

Whereas the idea behind discontinuity explains the severe adjustment problems confronting regions, the notion of spatial indeterminacy suggests that it is impossible that their ability to adapt

is determined by past experiences. Due to a mismatch with the new requirements, spatial practices and conditions that have been accumulated in the past, will not provide any stimuli to the development of new industries and, therefore, will not predetermine where they will emerge. This view stands in contrast with a widely-held belief in location theory that claims that new industries will develop most rapidly in those regions where their static, quasi-fixed, pregiven locational needs (for instance, a highly skilled population) can be most effectively matched with local conditions accumulated in the past (Hall, 1985). Their spatial manifestation should be regarded then as `... essentially random and indifferent to the specificities of place ...' (Gordon, 1991, p. 178) rather than as an automatic and predictable outcome of spatial structures and practices laid down in the past. Accordingly, many spatial outcomes are possible. We will not take the view, however, that potential impacts of space should be neglected, a topic to which we shall return in Section 3.3. There we will argue that this set of possible spatial outcomes may be more limited than is suggested here.

3.2 Creation of Production Space

The importance of spatial indeterminacy leaves room for human agency or creativity to be involved in the spatial formation of newly emerging industries. For reasons set out above, new industries can hardly draw on available conditions to support their development in space, which is why they must rely on their creative capacity to generate or attract their own supportive conditions in space (Storper and Walker, 1989). This creative ability compensates for the lack of stimuli from the spatial environment. In fact, new industries steadily create their favourable conditions (such as required labour, capital, suppliers, markets, institutions) *in situ* or attract them from outside, rather than being tied to preexisting, independent locational factors (Scott and Storper, 1987).

For this reason, it would be wrong to treat the local environment as a static selection mechanism. By contrast, newly emerging industries will shape and transform it according to their needs as their development proceeds. Hence, the local environment is likely to be adjusted to their requirements only in those places where new industries have actively manifested themselves. This implies that a supportive and efficient local environment is more likely to be an outgrowth of, rather than a pre-condition for the rise of new industries.

There is no reason to believe that the location where a new

industry emerges is necessarily the most efficient of all possible places. The lack of a favourable impact of the environment discussed previously implies that locations of new industries are unlikely to be selected, let alone the most suitable ones. In fact, it is difficult to think of optimal locations when the specific needs of new industries at their earliest stages of development are not pre-given but come gradually into being as these develop. We will turn to this issue in the next section. Even so, the presence of high returns in the early stages of growth, which results from patent protection, technological inappropiability and (temporary) price inelastic demand allows new industries to locate and survive in arbitrary places where, for example, `labor supplies are apt to be poor or inappropriate, linkages to relevant suppliers and buyers spotty, local markets weak, infrastructure poorly developed, and so forth' (Storper and Walker, 1989, p. 73). Moreover, the local presence of high costs is likely to be offset by the creative ability of new industries, because it brings efficiency in their local production environment.

Another implication is that the development of newly emerging industries at their initial stage of growth should be viewed as a creative process associated with the lack of a supportive environment, rather than as a process of positive feedback founded on the presence of favourable local conditions. However, this process of positive feedback, which is related to Veblen's notion of *cumulative causation*, may take place at a later stage of their development (see Storper, 1992). Then, entry barriers will be imposed on lagging regions. We will focus attention on this latter topic in Section 3.4.

The relevance of the creative ability may be illustrated by a historical example relating to Great Britain and Belgium (Boschma, 1994). The example is interesting because it challenges the common belief of economic historians that in the late eightteenth, early nineteenth century, given the poor transport facilities, a ready local access to coal and iron deposits could explain why regions endowed with such natural resources witnessed the rise of coke-based iron making and steam engineering. We will argue that, though a prerequisite, local supply of coal and iron ore was certainly not sufficient for regions to develop such dynamic industries. In fact, the development and growth of these new industries only became possible through the creative ability of firms to generate or attract a supportive local environment, because such a favourable environment was, to a high degree, lacking. This was achieved through, among other things, the import and creation of a (skilled) labour force (based on apprenticeship, on-the-job training, learning by doing), the development of a strong local network of techno-industrial

linkages between ancillary or complementary activities, the construction of a canal and railway infrastructure, and the supply of capital based on the practice of reinvested profits and, at a later stage, the establishment of new (local) joint-stock banks.

3.3. Spatial Accidents

In the foregoing, we have suggested that newly emerging industries may have a complete freedom to locate anywhere, due to their discontinuity (section 3.1) and creative ability (section 3.2). However, the WLO-concept rejects the view that their emergence takes place in a spaceless vacuum. In fact, technological change should not be understood as exogenous to space, but as interacting with its spatial context (Gertler, 1992). When spatial conditions vary markedly from place to place because of different histories, the capacity of regions to generate or attract new industries, and their ability to adapt their local environment, may also differ.

For this purpose, we will analyze here under what circumstances the foundation of new industries may actually depend upon, or be conditioned by, the spatial environment, and how to relate this to their discontinuity and creative ability in space. In other words, we will focus attention on whether the notions of spatial indeterminacy and creativity may still be valid when situating newly emerging industries in their local context. Taking into account of what has been said in section 2.2, we will successively examine those situations in which regions (a) provide initial triggers or incentives in terms of location-specific problems and opportunities, or (b) offer a local environment favourable to meet the new requirements of new industries. By doing so, we will examine the extent to which random events are still involved in the spatial emergence of new industries.

a Triggers

As has been set out in Section 2, major innovations may be triggered by existing (spatial) structures and practices, that reveal specific problems (factor scarcity, conflictual industrial relations, environmental threats, technological bottlenecks) or demands (market pressures, government regulations). We will claim that, contrary to the local character of searches along trajectories (section 2.1), it is rather uncertain and unpredictable where triggers will actually induce the emergence of new industries. This may, firstly, be related to the

evolutionary view that regards technological breakthroughs as unpredictable, unexpected outcomes of searches (Nelson and Winter, 1982; Mokyr, 1990). Moreover, small, arbitrary events, or even accidents are likely to be involved, which are hard to generalize about (Arthur, 1989). Further, we can think of general triggers, which are anything but confined to particular places, like high input costs (oil prices, labour costs) or government regulations (restrictive environmental policy). Another reason for the uncertainty about the location of new industries is the fact that there is an infinite number of location-specific potential triggers, that are present in every possible type of region. In fact, it remains an open question why certain potential triggers set in motion the development of new industries in particular regions, and why others (in the same or other regions) do not. We are dealing here with a fundamental problem of uncertainty and unpredictability *ex ante* concerning the actual spatial manifestation of new industries. This is illustrated in Figure 1, which shows the presence of many potential location-specific triggers in all of ten distinct regions in a country, but induce major innovations in only three of them. Although each of these major innovations can be related to a location-specific trigger, they may still be regarded as accidental events, because we cannot explain why similar innovations did not occur in the other regions. This reasoning is similar to the selection processes determining choices of technology set out by Arthur (1989): the actual outcome largely depends on small, arbitrary events, magnified by a positive feedback mechanism, which, in our approach, is achieved by the creative ability of firms building up a favourable local production milieu around them.

b Selection Environment

Once triggered, it is not unlikely that a particular spatial environment, that provides a mixture of constraints, advantages and capabilities carried over from the past may be more beneficial for, or more responsive to the development of new industries than others. This is exactly what the notions of *heredity* and *selection* in evolutionary thinking are about (Metcalfe, 1989). We want to point out again, however, that it still is not possible to predict where new industries will emerge.

We already explained in Section 2 that the selection environment consists of many potentially influential elements of a technological, economic, political, social and institutional nature. Moreover, these will only determine their location in case these are spatially differentiated. Even so, it has already been pointed out before that the discontinuity of new industries implies that potentially favourable

impacts of the local environment are likely to be rather weak, because they hardly meet their requirements. Even more so because the specific needs of new industries are often not given but come into being as a result of their development in the regions concerned. In this respect, it is essential to make a distinction between so-called `generic' and `specific' conditions: in their initial stage of growth, new industries can only make use of generic, non-specific resources (basic knowledge and skills). As their growth proceeds, their creative ability turns out to be an essential mechanism, because it transforms the generic resources into specific ones (highly skilled labour, specialized knowledge). It may seem rather paradoxal that such discontinuity leads to the conclusion that the creation of a suitable production milieu, based on such generic resources may be regarded as a rather gradual process, that steadily emerges out of its surrounding environment. In fact, it is this discontinuity that explains why the growth of the new industry smoothly transforms the local milieu to serve its development.

It may imply that regions endowed with particular generic conditions may, to a certain extent, be fitter to adjust than other regions. The WLO-concept claims, however, that potentially favourable generic conditions are likely to be widely available in space, while these will only influence rather than determine the ability of regions to adjust. Though the local presence of generic conditions may be regarded as potentially beneficial, it is far from sufficient to sustain the rise of new industries. In sum, the emergence of a new industry in a particular region may be described as a rather adventitious process; the beneficial, generic conditions are unlikely to be confined to only this succesful region. Its creative ability may not prevent the development of the new industry in regions where those generic, potentially favourable resources are absent.

This is illustrated in Figure 1. The rise of a new industry in region A may be explained by its potentially favourable environment. However, it may also be viewed as a rather accidental event, because we cannot provide an explanation for the fact that other regions endowed with similar beneficial conditions did not succeed to develop the new industry. The only thing we can explain is that regions lacking such basic requirements are more likely to fail to generate new industries. This is shown in Figure 1 by region B, where a major innovation induced by a local trigger did not give rise to a new, fully-developed industry. This touches upon the way of reasoning common to evolutionary theory, that is to explain "... *what is not* likely to occur ..." (De Bresson, 1987, p. 754). One should, however, not forget that superprofits, for instance, do not stop new industries from developping in unfavourable,

high cost regions as well. In fact, Figure 1 illustrates a case, where region C shows an ability to generate a new industry, despite its unfavourable production milieu. Here, we can argue that its creative ability, which includes drawing resources (skilled labour) from surrounding regions endowed with favourable environments (illustrated by the arrows drawn in Figure 1) has been able to offset the lack of local stimuli. The fundamental problem here is that we cannot explain why region C was able to do so, and why region B was not.

- Figure 1 -

We will briefly illustrate this adventitiousness of the spatial pattern of new industries on the basis of two examples derived from a long-term spatial study of Great Britain and Belgium (Boschma, 1994). In both cases we will relate the rise of a particular new industry to a favourable local environment, determine whether such an environment was confined to the host regions involved, and assess the importance of the ability of the new industry to create its own supportive local environment.

The first example relates to the rise of the mechanized cotton industry in some textile regions (Lancashire and Ghent) in both countries in the late eightteenth and early nineteenth century. There, the new textile mills could profit from favourable conditions associated with local linen and wool trades, such as pools of skilled entrepreneurs, readily available reservoirs of experienced labour, and established networks of suppliers and markets. In fact, a tradition of a domestic `putting-out' system had led to a local accumulation of skills and experience in this semi-capitalist type of production. This facilitated the inflow of required labour in the new textile mills in those regions (Marshall, 1987). Further, local networks of suppliers and buyers, linked into a chain of successive stages of textile production (spinning, weaving, bleaching, printing) favoured the absorption of the strongly growing cotton output. These favourable conditions should, however, not be regarded sufficient; many textile areas in Britain and Belgium endowed with similar conditions were unable to participate in this new sector. Furthermore, the innovative firms showed a well-developed capacity to create or attract their own beneficial conditions *in situ*. In fact, the rise of specialized (textile) machine-building firms and the rapid expansion of heavy chemicals (Leblanc soda and bleaching powder) in these dynamic textile regions were largely a response to the rapid

mechanization of the cotton industry, supporting its subsequent development. Moreover, required skills had to be created locally through practical experience and on-the-job-training within the firms themselves, in order to compensate for the lack of skills and the absence of a technical education system. Firms also depended heavily on a massive inflow of labour (from Ireland in the case of Britain, from England in the case of Belgium) to secure the mobilization of necessary workers for the new textile mills. They managed to avoid the traditional labour force by making use of untapped, more disciplined segments of labour supply such as women and children, which were widely available.

The second example refers to newly emerging industries such as electrical engineering and automobiles, that developed in a range of British and Belgian areas during the late nineteenth and early twentieth century. These localities were characterized by a multiplicity of metalworking, engineering and instrument trades, from which were drawn pools of readily available experienced labour and skilled entrepreneurs. However, the randomness of their spatial appearance may be related to the fact that these trades were widely available in space at that time in both Britain and Belgium: many regions involved in these trades in the past were incapable of reaping the benefits from these new industries. Further, the importance of their creative ability may be briefly illustrated by the fact that these initial developments were at a later stage followed by the establishment of supportive technical schools (for instance, King's College in London) in the regions concerned. These were created and financed by the local firms themselves to overcome the lack of skilled personnel and the absence of government involvement (see Boschma, 1994).

3.4 Spatial Dynamics: Windows of Locational Opportunity

In the previous section we presented a theoretical concept, that adopted a particular view with respect to the extent to which chance and necessity are involved in the spatial manifestation of newly emerging industries. The WLO-concept is used to describe the mechanisms behind the location of new industries in terms of spatial indeterminacy, creativity and randomness. By doing so, one can account for the fact that newly emerging industries are likely to develop rather independently of established spatial structures and conditions.

From the WLO-perspective, we will now focus attention on the problem whether these novelties may bring about elements of flux or stability in the long-term evolution of the spatial system, a topic which

is regarded central to evolutionary thinking (see Nelson, 1995). This pertains to the question to what extent the evolution of the spatial system is subject to fundamental change when new industries emerge, that is to what extent these novelties require so-called new growth regions rather than old industrial regions to develop. We will relate this to the notions of indeterminacy, creativity and randomness discussed above. According to the WLO-concept, the long-term evolution of the spatial system is in principle unstable. The discontinuity of major innovations, combined with their disruptive impacts described in section 2.2 is likely to change the ability of regions to generate or attract new industries in the course of time. Major innovations often create opportunities for lagging and backward regions, whereas leading regions are not necessarily winners in many cases. However, there still is much uncertainty about whether regional dynamics take place because there is much uncertainty about the location where the new industry will sprang up: the location of new industries is probably not determined by any specific, beneficial factors.

Empirical evidence lends support to the view that long-term structural shifts in techno-industrial leadership between regions have actually taken place in the major industrial countries. Former leading regions are often unable to maintain their dominant positions. We have illustrated this in table 2 for Great Britain and Belgium. In this table the long-term evolution of regions is presented on the basis of their relative shares in employment in (clusters of) innovative industries, so-called location quotients. A quotient higher than one indicates that a region's number of employment in the innovative sectors exceeds the national average (Boschma, 1994). It is evident from the data that both Wallonia and the north of Britain were already losing their dominant position by 1910. It is completely vanished by 1950. At the same time new industrial regions emerge in Flanders and the south of England to become prominent in 1950. The difference between the regions in terms of their ability to generate or attract new (clusters of) innovative industries has disappeared. Moreover, it has been demonstrated in many studies that these newly emerging industrial regions in both countries have consolidated and often improved their performance in the post-war period (see, for instance, Hall and Preston, 1988; Boschma, 1994).

- Table 2 -

The outcomes seem to support the widely-held view that new

industries will emerge in regions different from those where traditional industries are declining, due to so-called `inhibiting inheritances' in specialized industrial regions (Hall, 1985). The ability of this latter type of region to generate new industries is often considered to be weakened or eroded in the course of time, because they become too strongly orientated towards their techno-industrial legacy of the past, a topic which has also been addressed in section 3.1 (see, for instance, Rees, 1979; Markusen, 1985; Booth, 1986; Norton, 1992).

Our claim is here that it is uncertain whether major innovations cause instability in the long-term evolution of the spatial system in terms of substantial shifts between techno-industrial positions of regions. There are several reasons for this. Recent processes of structural adjustment in some traditional industrial regions (Boston area, Jura region, Ruhr area) have demonstrated that the loss of techno-industrial leadership and a structural process of decay are anything but inevitable destinies of this type of regions. Moreover, we argued earlier that the spatial pattern of existing advantages and constraints accumulated in the past may be hardly of relevance because of the discontinuity of major innovations. In fact, the creative ability of new industries should be able to offset any hindrances, including the earlier mentioned negative lock-in effects, whereas the rather accidental nature of their spatial formation (their sensitivity to small, arbitrary factors) leaves open many possibilities.

We will, therefore, make use of the notion of window of locational opportunity, because it incorporates the uncertainty with respect to regional dynamics. The WLO-concept has also been used elsewhere, though in a slightly different way (see Scott and Storper, 1987; Perez and Soete, 1988; Storper and Walker, 1989). In our view windows of locational opportunity open up in the event of newly emerging industries. New industries develop independently of established spatial structures because of their discontinuity, creativity and randomness. It is uncertain whether major techno-industrial changes cause regional dynamics, because it is uncertain where new industries will emerge. For this reason, it is probable but not inevitable that major innovations bring about regional dynamics. In fact, we may, for example, not rule out the possibility that a new industry emerges in traditional industrial regions, consolidating their dominant position in the spatial system, although hardly any conditions present in those regions could be held responsible for this. Hence, it is uncertain whether the long-term evolution of the spatial system is subject to major instability as a result of major innovations. In sum, the concept of window of locational opportunity claims that the long-term evolution of the spatial system is

potentially, but not necessarily, unstable.

The concept of window of locational opportunity may be related to the two notions of innovation described in Section 2 and summarized in Table 1. The notion of discontinuous innovation and the notion of continuous innovative behaviour along trajectories may be succesively associated with disruptive and cumulative tendencies in the long-term evolution of the spatial system, wherein windows of locational opportunity may succesively open and close in the course of time (see also Storper and Walker, 1989). In fact, the rather indeterminate spatial manifestation of new industries may be followed by a logic of cumulative, self-reinforcing tendencies of spatial development.

This may be explained by an ideal type stage-model of a new industry in space, which has been summarized in Table 3. In the first stage of their growth cycle, new industries may emerge spontaneously in arbitrary places, which may upset the foundations of the spatial system. The discontinuity and randomness of major innovations implies that the spatial emergence of new industries is unlikely to reveal predictable tendencies of necessity and regularity, because specific structures and conditions laid down in the past are unlikely to determine their location. For example, their extreme sensitivity to a multitude of small, arbitrary triggers in space and the importance of generic resources during their initial phase of development imply that new industries may well develop in a variety of alternative locations. In other words, the windows of locational opportunity are widely open at this stage of development. The next stage of development is characterized by a cumulative, self-reinforcing development in a few selected places, which exercises longlasting exclusion effects on lagging regions. This is achieved by a self-reinforcing feedback between the continuous nature of innovative behaviour along trajectories, the build-up of localization economies, the creation and development of specific knowledge resources, the build-up of a socio-cultural climate of consensus and commitment often materialized in particular institutions (inter-firm associations, government regulations, industrial relation systems, educational and research facilities, financial organizations) and strong local economic growth within these dynamic regions. In fact, successive rounds of innovative behaviour and local growth bring about higher volumes of output, which allow the dynamical regions to benefit from economies of scale, higher rates of specialization and more agglomeration advantages like a larger, more diversified labour market, an accumulated pool of skills, knowledge and experience, a larger supply of capital, a better provision of infrastructural facilities, and so forth. Once the spatial system has entered this phase, change will become merely marginal: the

unfolding of cumulative, self-reinforcing development tends to reinforce the persistence of regional disparities, because the leading regions continue to stay ahead at the expense of lagging regions. Hence, the windows of locational opportunity have closed around the most dynamic areas, while entry barriers or exclusion effects have been imposed on lagging regions.

- Table 3 -

3.5 Two Types of Spatial Change

By and large, the notion of discontinuous innovations plays an essential part in the foregoing, because it is strongly related to the notions of spatial indeterminacy, creativity and randomness discussed above. Nevertheless, it remains an open question to what extent each major innovation actually give evidence of a sharp discontinuity in space, that is how big is the discrepancy between the new needs of the major innovation and the local environment inherited from the past. We think it is a big challenge for future research to define and measure this discrepancy empirically, because it would increase our understanding of evolutionary notions like fitness and selection. Moreover, this sort of analysis may be regarded as essential to determine whether novelties reflect gradual, evolutionary rather than dramatic, discontinuous changes in spatial economies.

For this purpose, we present in Table 4 an analytical framework, which attempts to shed light on the problem how to define spatial discontinuity. We suggest that the rate of discontinuity of each major innovation may be assessed in terms of the extent to which it can build on a local environment when the new industry has to organize its required inputs (labour, capital, technological knowledge and other inputs) and to serve its markets. We take also into account whether it can benefit from existing facilities provided by the (local) government.

If a major innovation can hardly draw on available local conditions to support its development in space, it will be associated with a revolutionary tendency of spatial change: it would reveal deep techno-industrial cleavages in the evolution of spatial economies. Because of this fundamental shortage of necessary resources, new industries have to rely on their creative ability in order to mobilize or attract these themselves. As shown in Table 4 for example, new skills and flexible

labour at their initial stage of development will be acquired in this case by on-the-job training, the start-up of new learning trajectories, the creation of new (or the adaptation of old) educational institutes, the inflow of external labour, and the use of new flexible labour segments. We already presented at an earlier stage in this chapter examples of the spatial emergence of new industries in Great Britain and Belgium that could be associated with this revolutionary type of change.

By contrast, an evolutionary tendency of spatial change will then be associated with situations in which new industries can build to some extent on existing local (though often generic) conditions when adjusting the local environment in accordance with their needs. In this latter case, a continuous framework would be more appropriate to explain their spatial emergence. As shown in Table 4 for example, new skills required at their initial stage of growth may be acquired in this case by building on and applying existing skills, knowledge and experience accumulated in established local firms, educational facilities and the local environment. There are examples of new techno-industrial sectors that emerged in the last two centuries in Great Britain and Belgium, that could be associated with this evolutionary type of spatial change. These sectors could largely build on structures carried over from the past, strongly related to, and often actually incorporated in traditional activities in the regions concerned. This is, for example, true for highly innovative industries such as iron making, mechanical engineering and steel making in the nineteenth century, that were erected upon the foundations of heavy industrial complexes laid down in the preceding era of the first Industrial Revolution. It was this supportive environment that largely determined the locations of these industries. The ability of established (iron) firms to divert into these related techno-industrial fields could be attributed to the local accumulation of large sums of fixed capital (creating entry barriers for new regions), localization economies (skills, experience, infrastructure) and strong local linkages between major up- and downstream activities. This led to a consolidation of the leading positions of established iron regions in both countries. Indeed, it seems that the windows of locational opportunity never really opened up in these situations.

- Table 4 -

The WLO-concept may be related to the two types of spatial change that are distinguished here. To begin with, the windows of locational

opportunity are likely to be widely open if a revolutionary process of spatial change is involved, because it reflects a high rate of spatial discontinuity. Because the new industry can hardly draw on local conditions to support its growth in this case, each type of region starts from a more or less equal position and, thus, has more or less the same probability to host the new industry despite the fact that their histories may differ considerably. Hence, the new industry provides an opportunity for lagging regions to escape the vicious circle of former constraints and exclusion effects, while leading industrial regions can no longer build on local advantages related to their techno-industrial leadership. There is thus much uncertainty not only about the place where the new industry will germinate, but also about whether regional dynamics may take place.

This last mentioned point also applies to the evolutionary type of spatial change. The windows of locational opportunity will, however, be opened up to a lesser extent in this case because a relatively lower rate of spatial discontinuity is involved. As set out in section 3.3, the creative ability of the new industry in this case can build to some degree on particular (though often generic) conditions inherited from the past. That is why regions endowed with these potentially favourable conditions have a higher probability to generate and develop the new industry. The probability still depends, however, on the extent to which these (locally available) conditions may be regarded as essential to develop the new industry, and on the extent to which these may also be created *in-situ* in order to compensate for their absence. We mentioned in section 3.3, for example, that their often generic nature may imply that they are likely to be widely available in space, whereas the creative ability may not prevent the development of the new industry in regions which lack generic, potentially favourable resources. In other words, it is still very likely that the windows of locational opportunity are widely open when an evolutionary type of spatial change is involved, although the rate of openeness is expected to correlate positively with the degree of spatial discontinuity.

4. Conclusion

In this chapter we employed the `window of locational opportunity'-concept to answer the question whether the spatial emergence of novelties, such as major innovations that give birth to new industries, should be attributed to chance events rather than deterministic mechanisms, and how this relates to the particular nature of change in

the long-term evolution of the spatial system. By doing so, we accounted for a complex interplay between spontaneity, creativity, randomness and windows of locational opportunity.

We have specified whether elements like indeterminacy, human agency and chance are involved in the spatial formation of newly emerging industries. We came to the conclusion that their discontinuity and randomness imply that their spatial pattern does probably not reveal predictable tendencies of necessity and regularity, because spatial structures, conditions and capabilities laid down in the past are unlikely to determine their spatial manifestation. This happens in spite of the fact that new industries may be induced or triggered by existing practices and structures which provide opportunities and/or challenges. This is also despite the fact that the formation of new industries may be influenced by the production environment, that is facilitated in regions endowed with beneficial (though generic) conditions. Nevertheless, such potential impacts of space were considered to be highly unpredictable: latent triggers or incentives are manifold, while the selection environment may operate very weakly. In fact, we claimed that their discontinuity actually necessitated the incorporation of notions of human agency and accidents to `explain' the spatial pattern of new industries, because the selection environment will not provide a full explanation for the location of novelty.

Because there is much uncertainty about the site where new industries will emerge, windows of locational opportunity tend to open up in the event of newly emerging industries: because of their discontinuity, creativity and randomness they are likely to bring about regional dynamics, without requiring so-called new regions instead of old industrial regions to develop. In other words, the WLO-model holds the view that the long-term evolution of the spatial system is potentially unstable.

In our view future research should focus more on the problem of how to define and specify the rate of discontinuity of novelties, because this would increase our understanding of evolutionary notions like fitness and (the potential impact of) the selection environment. According to Hodgson (1993), `such a standpoint avoids the extremes of either determinism or complete indeterminacy' (p. 224). In fact, we share the idea expressed by De Bresson (1987) and Hodgson (1993) that evolutionary theory should explicitly focus attention on the reduction of the possible range of outcomes and, at the same time, clarify why it is impossible to predict and determine exactly when and where novelties will emerge.

5. References

Andersen, E.S. (1994), Evolutionary economics. Post-Schumpeterian contributions, London: Pinter Publishers.

Arthur, W.B. (1989), 'Competing technologies, increasing returns, and lock in by historical events', The Economic Journal 99, pp. 116-31.

Booth, D.E. (1986), 'Long waves and uneven regional growth', Southern Economic Journal, 53 (1), July, pp. 448-60.

Boschma, R.A. (1994), Looking through a window of locational opportunity. A long term spatial analysis of techno-industrial upheavals in Great Britain and Belgium, PhD Thesis, Tinbergen Institute Research Series no. 75, Amsterdam: Thesis Publishers.

Boyer, R. (1988), 'Technical change and the theory of régulation', in Dosi, G., C. Freeman, R. Nelson, G. Silverberg, L. Soete (eds.), Technical change and economic theory, London: Pinter Publishers, pp. 67-94.

Camagni, R. (ed.) (1991), Innovation networks: spatial perspectives, London/New York: Belhaven Press.

Chapman, K. (1992), 'Continuity and contingency in the spatial evolution of industries: the case of petro-chemicals', Transactions of the Institute of British Geographers, 17, pp. 47-64.

Crafts, N.F.R., 1977, 'Industrial Revolution in England and France. Some thoughts on the question: why was England first', The Economic History Review 30, pp. 429-41.

David, P.A. (1985), "Clio and the economics of QWERTY", American Economic Review, vol. 75, no. 2, pp. 332-7.

De Bresson, C. (1987), 'The evolutionary paradigm and the economics of technological change', Journal of Economic Issues, vol. 21, no. 2, pp. 751-62.

Dicken P. and P.E. Lloyd (1990), Location in Space; Theoretical Perspectives in Economic Geography, 3rd edition, New York: Harper & Row.

Dockès, P. and B. Rosier (1992), 'Long waves and the dialectic of innovations and conflicts', in Kleinknecht, A., E. Mandel & I. Wallerstein (eds.), New findings in long-wave research, London: Macmillan, pp. 301-15.

Dosi, G. (1982), 'Technological paradigms and technological trajectories; a suggested interpretation of the determinants and directions of technical change', Research Policy, 11, pp. 147-62.

Dosi, G. (1984), Technical change and industrial transformation; the theory and an application to the semiconductor industry, London: MacMillan.

Dosi, G. and L. Orsenigo (1988), 'Coordination and transformation: an overview of structures, behaviours and change in evolutionary environments', in Dosi, G., C. Freeman, R. Nelson, G. Silverberg and L. Soete, (eds.), Technical Change and Economic Theory, London: Pinter Publishers, pp. 13-38.

Freeman C., J. Clark and L. Soete (1982), Unemployment and Technical Innovation; a Study of Long Waves and Economic Development, London: Frances Pinter.

Freeman C. and C. Perez (1988), 'Structural crisis of adjustment: business cycles and investment behaviour', in Dosi G., C. Freeman, R. Nelson, G. Silverberg and L. Soete (eds.), Technical Change and Economic Theory, London: Pinter Publishers, pp. 38-66.

Gordon, R. (1991), 'Innovation, industrial networks and high-technology regions', in Camagni R. (ed.), Innovation networks: spatial perspectives, London/New York: Belhaven Press, pp. 174-95.

Hall, P. (1994), Innovation, economics and evolution. Theoretical perspectives on changing technology in economic systems, London: Harvester Wheatsheaf.

Hall, P.G. (1985), 'The geography of the fifth Kondratieff', in Hall P.G., and A.R. Markusen (eds.), Silicon landscapes, Boston: Allen & Unw-in, pp. 1-19.

Hall, P.G. and P. Preston (1988), The carrier wave; new information technology and the geography of innovation 1846-2003, London: Unwin Hyman.

Heiner, R.A. (1983), 'The origin of predictable behaviour', The American Economic Review, 73, pp. 560-95.

Hodgson, G.M. (1993), Economics and evolution. Bringing life back into economics, Cambridge: Polity Press.

Hodgson, G.M. (1991), 'Socio-political disruption and economic development', in G.M. Hodgson and E. Screpanti (eds.), Rethinking economics. Markets, technology and economic evolution, Aldershot: Edward Elgar, pp. 153-171.

Hodgson, G.M. and E. Screpanti (eds.) (1991), Rethinking economics. Markets, technology and economic evolution, Aldershot: Edward Elgar.

Hudson, P. (1992), The industrial revolution, London: Edward Arnold.

Kleinknecht, A. (1990), 'Are there Schumpeterian waves of innovation?', Cambridge Journal of Economics 14, pp. 81-92.

Klepper, S. and E. Graddy (1990), 'The evolution of new industries and the determinants of market structure', RAND Journal of Economics, vol. 21, no. 1, pp. 27-44.

Kuhn, T. (1970), The structure of scientific revolutions, Chicago: University of Chicago Press.

Leydesdorff, L. & P. van den Besselaar (eds.) (1994), Evolutionary economics and chaos theory. New directions in technology studies, London:

Pinter Publishers.
Lipietz, A. (1986), 'New tendencies in the international division of labor: Regimes of accumulation and modes of regulation', in Scott, A.J. and M. Storper, (eds.), Production, Work, Territory: the Geographical Anatomy of Industrial Capitalism, London: Allen & Unwin, pp. 16-40.
Markusen, A. (1985), Profit cycles, oligopoly and regional development, Cambridge: MIT Press.
Marshall, M. (1987), Long waves of regional development, London: MacMillan.
Metcalfe, S. (1989), 'Evolution and economic change', in A. Silberstone (ed.), Technology and economic progress, London: Macmillan, pp. 54-85.
Metcalfe, S. (1994), 'Evolutionary economics and technology policy', The Economic Journal, vol. 104, pp. 931-44.
Mokyr, J. (1990), The lever of riches. Technological creativity and economic progress, New York: Oxford University Press.
Mokyr, J. (1991), 'Evolutionary biology, technological change and economic history, Bulletin of Economic Research, vol. 43, no. 2, pp. 127-49.
Nelson, R.R. and S.G. Winter (1982), An evolutionary theory of economic change,Cambridge: Cambridge University Press.
Nelson, R.R. (1995), 'Recent evolutionary theorizing about economic change', Journal of Economic Literature, vol. 33, pp. 48-90.
Norton, R.D. (1979), 'Agglomeration and competitiveness from Marshall to Chinitz', Urban Studies 29 (2), pp. 155-70.
Perez, C. (1983), 'Structural change and the assimilation of new technologies in the economic and social systems', Futures 15 (5), pp. 357-75.
Perez, C. and L. Soete (1988), 'Catching up in technology: entry barriers and windows of opportunity', in Dosi, G., C. Freeman, R. Nelson, G. Silverberg and L. Soete, (eds.), Technical Change and Economic Theory, London: Pinter Publishers, pp. 458-79.
Pollard, S. (1981), Peaceful conquest; the industrialization of Europe 1760-1970, Oxford: Oxford University Press.
Prigogine, I. and I. Stengers (1984), Order out of chaos, London: Fontana.
Rees J. (1979), 'Technological change and regional shifts in American manufacturing', Professional Geographer 31, pp. 45-54.
Rigby, S.H. (1995), 'Historical causation: is one thing more important than another?', History, vol. 80, no. 259, pp. 227-42.
Rosenberg N. (1976), Perspectives on Technology, Cambridge: Cambridge University Press.
Rosenberg, N. (1982), Inside the black box: Technology and economics,

Cambridge: Cambridge University Press.
Rosenberg N. and C.R. Frischtak (1983), 'Long waves and economic growth; a critical appraisal', American Economic Review, Papers and Proceedings 73, pp. 146-51.
Scott, A.J. and M. Storper (1987), 'High technology industry and regional development: a theoretical critique and reconstruction', International Social Science Journal 112, pp. 215-32.
Scott, A.J. and M. Storper (1992), 'Industrialization and regional development', in Storper, M. and A.J. Scott, (eds.), Pathways to Industrialization and Regional Development, London/Boston: Routledge, pp. 3-17.
Silverberg, G. (1988), 'Modelling economic dynamics and technical change: mathematical approaches to self-organisation and evolution' in Dosi,G., C. Freeman, R. Nelson, G. Silverberg and L. Soete, (eds.), Technical Change and Economic Theory, London: Pinter Publishers, pp. 531-59.
Storper, M. and R. Walker (1989), The capitalist imperative; territory, technology and industrial growth, New York: Basil Blackwell.
Storper, M. (1992), 'The limits to globalization; technology districts and international trade', Economic Geography 68 (1), January, pp. 60-93.
Teece, D. (1988), 'Technological change and the nature of the firm' in Dosi, G., C. Freeman, R. Nelson, G. Silverberg and L. Soete, (eds.), Technical Change and Economic Theory, London: Pinter Publishers, pp. 256-81.
Utterback, J. and F. Suarez (1993), 'Innovation, competition, and market structure', Research Policy, vol. 22, no. 1, pp. 1-21.
Witt, U. (1991), 'Reflections on the present state of evolutionary economic theory', in G.M. Hodgson and E. Screpanti (eds.), Rethinking economics. Markets, technology and economic evolution, Aldershot: Edward Elgar, pp. 83-102.
Witt, U. (1993) (ed.), Evolutionary economics, Aldershot, Hants: Edward Elgar.

Table 1. The main differences between the two notions of innovation

	the notion of continuous innovation	the notion of discontinuous innovation
- nature of innovation	small, incremental	radical
- role of history	continuous, cumulative, routine-guided changes	discontinuous, breaks with the past
- triggers	local problems and opportunities within existing routines	accidents, small and arbitrary events, many potential triggers
- selection environment	strong selection due to role of supporting environment	weak selection due to lack of stimuli: creative behaviour
- predictable pattern of change	high	low
- economic impact	small, cumulative impact may be large	large, especially in the case of clusters
- economic dynamics	dynamic stability	instability and transformation
- firms	mostly established firms due to firm-specific advantages	mostly newly created firms due to flexible nature
- institutional structure	relatively good match: in general supporting	mismatch: structural crisis of adjustment, transformation

Figure 1. An illustration of the accidental way in which new industries emerge in space

Table 2. The long-term ability of selected regions to participate in new techno-industrial fields in Belgium and Britain, expressed as location quotients

Belgium	**1846**	**1910**	**1947**
Wallonia			
- Mons	5.73	1.16	1.30
- Charleroi	5.39	2.74	1.35
- Liege	4.21	2.16	0.99

Flanders			
- Antwerp	0.04	0.98	1.79
- Brussels	0.42	1.47	1.53
- Turnhout	0.12	0.33	1.34
Great Britain	**1841**	**1911**	**1951**
North			
- Lancashire	3.02	1.13	0.84
- Strathclyde	2.96	1.81	1.26
- North East	1.43	1.17	1.16
- South Wales	2.21	0.82	0.97
South			
- South East	0.14	0.87	1.03
- West Midlands	0.85	1.31	1.69

Source: Boschma, 1994

Table 3. The two sequential stages of discontinuous and cumulative development of a new industry in space

	the first stage of discontinuous evolution	the second stage of cumulative evolution
- nature of spatial pattern	arbitrary places: optimization irrelevant	spatial clustering: localized external economies
- origins of spatial pattern	spatial indeterminacy	cumulative mechanisms in space: localization economies
- footlooseness	high	low

- predictability	low	high
- windows of locational opportunity	open	closed
- dynamics in spatial system	potentially unstable but uncertain	relatively stable and fixed

Table 4. Two ideal types of spatial change

	evolutionary tendency of spatial change	revolutionary tendency of spatial change
new labour	builds on existing skills and experience in local trajectory/ firms, educational system facilities/inflow and local environment	old skills obsolete: on-the-job training/new learning new educational external labour/ flexible labour
new capital	addition to old capital: provision by established firms and existing local capital suppliers	replacement old capital:provision by new firms (family capital, reinvested profit)/ new suppliers venture capital/ external capital
new techno-knowledge	builds on and reinforces applicability of existing knowledge (R&D, experience)	old knowledge irrelevant: new technological trajectory/ new R&D facilities/ inflow of external

		knowledge
new input of supplies	builds on existing capability of current suppliers	new inputs: inhouse production firms/ creation of new suppliers/ inflow of external supplies
new markets	new product sold on new or established market: use of existing market knowledge	new markets: substitution of old markets/ creation of new markets/ supply of external markets
new government institution	minor adjustments established knowledge, capital, law and infrastructural institutions: builds on existing ones	dysfunctioning of established institutions: new knowledge and capital institutions/ new regulations/ new infrastructure